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THE PREDISPOSITION OF STREPTOCOCCUS CARRIERS TO THE COMPLICATIONS OF MEASLES

RESULTS OF SEPARATION OF CARRIERS FROM NON-CARRIERS AT A BASE HOSPITAL *

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It is evident from reports coming from various Army cantonments[1] that measles, because of the severity and frequency of its complications, must be regarded as a serious camp disease. Complications necessitate long hospitalization and cause, therefore, a high noneffective rate; bronchopneumonia and empyema have been responsible for many deaths. With surprising uniformity, the complications have been due to infection with a hemolytic streptococcus.

In the report of a commission[2] sent by the Surgeon-General of the Army to study the pneumonia at San Antonio, Texas, two significant facts concerning the relation of the streptococcus to the complications of measles were pointed out: First, a relatively small number of measles patients (11.4 per cent.) harbored this organism in their throats on admission to the hospital; second, many more acquired *S. hemolyticus* in their throats for the first time during their stay in the

* From the Medical and Laboratory Services, Base Hospital, Camp Zachary Taylor, Ky.

1. Duncan, L. C., and Sailer, J.: An Epidemic of Measles and Pneumonia in the Thirty-First Division, Camp Wheeler, Georgia, Mil. Surg., 1918, **42**, 123. Hamburger, W. W., and Mayers, L. H.: Pneumonia and Empyema at Camp Zachary Taylor, Ky., THE JOURNAL A. M. A., March 30, 1918, p. 915. Irons, E. E., and Marine, David: Streptococcal Infections Following Measles and Other Diseases, THE JOURNAL A. M. A., March 9, 1918, p. 687. Cumming, J. G., Spruit, C. B. and Lynch, Charles: The Pneumonias: Streptococcus and Pneumococcus Groups, THE JOURNAL A. M. A., April 13, 1918, p. 1066.

2. Cole, Rufus, and MacCallum, W. G.: Pneumonia at a Base Hospital, THE JOURNAL A. M. A., April 20, 1918, p. 1146.

wards. It was therefore inferred that at Fort Sam Houston, at least, the high incidence of bronchopneumonia and empyema during convalescence from measles might be directly related to the transfer of the infectious agent from one patient to another in the wards of the hospital.

PLAN OF THE PRESENT STUDY

Ward Routine.—On admission to the hospital, all measles patients were sent to a special "measles receiving ward," which was divided into cubicles by sheets, and where every patient was required to remain in bed. Each day throat cultures were taken on those admitted during the preceding twenty-four hours. Carriers of *S. hemolyticus* were on the following morning sent to the "dirty" wards. Those whose cultures were negative for this organism were held for another day, and if a second swabbing confirmed the findings of the first, were sent to the "clean" wards. Rarely did the result of a second culture contradict the report of the preceding day. All patients in each ward were swabbed again at least once a week. On discovering that a "clean" patient had become a carrier in the hospital, he was promptly transferred to a "dirty" ward.

A separate ward was set aside for the reception of post-measles pneumonia, to which, immediately on the recognition of this complication, patients were transferred.

In both "clean" and "dirty" wards, cubicle isolation was strictly observed. Each patient was provided with a gauze mask, changed every twenty-four hours, and was required to wear this mask constantly when not in his own cubicle. For infringements of this rule, punishments were meted out by the ward surgeon, who also daily gave a short talk to ward personnel and patients on the rationale of the various measures for isolation. In this way better coöperation was insured.

Ward surgeons, nurses and orderlies, when in the ward, were properly masked and gowned.

All patients, in bed or convalescent, were fed in their own cubicles; three or more waiters, chosen from among the convalescents, served the food. At all times, but especially during meal hours, crowding together was prohibited; each man ate either in bed

or at his own bedside. In the washroom, only one man was permitted at a time; in the latrines, the masks were worn and no more were allowed to enter than could be accommodated at any one time. A guard, changed every two hours and picked from among the convalescents, was stationed at the door of the latrine to insure the enforcing of these rules. No smoking was permitted.

It may well be asked why such rigid precautions were observed in wards in which only either carriers or noncarriers were cared for, and why these measures are described in detail. As pointed out by Cole, and repeatedly confirmed in our own experience, *S. hemolyticus* is very readily transferred from one individual to another, and no matter how strict the supervision, an occasional lapse in discipline is bound to occur. The slightest break in the chain of precautions may result in disaster. For example, in a "clean" ward, throat cultures made at intervals of a few days revealed the fact that several "clean" cases were being converted into carriers. On swabbing the personnel of the ward, it was found that two orderlies and a nurse harbored *S. hemolyticus* in profusion in their throats. On replacing these individuals with noncarriers, no further contamination occurred. This experience taught us to provide the clean wards with a personnel of noncarriers.

In the "dirty" wards, it is desirable to prevent one individual from becoming a carrier of another patient's strain of streptococcus; for different strains may vary in virulence. It is also worthy of note that among the 388 cases of measles described in this report, only two instances of cross-infection occurred, namely, two cases of mumps, probably admitted to the measles service in the incubation period of parotitis. Capps[3] has recently emphasized the value of masking in the prevention of cross-infection in contagious wards, and has outlined a number of ward measures similar to those here described.

Laboratory Technic.—Cultures from the pharynx and tonsils were taken at the bedside with straight swabs, which were then placed into about 1 c.c of beef infusion broth (+ 0.1), shaken and brought to the laboratory. There they were plated without incu-

3. Capps, J. A.: A New Adaptation of the Face Mask in the Control of Contagious Disease, THE JOURNAL A. M. A., March 30, 1918, p. 910.

bation on 10 per cent. human blood agar plates. In order to insure proper separation of colonies, it was essential to rinse each swab thoroughly by twirling it forcibly against the side of the test tube, then wiping it further at the periphery of the plate, and streaking lightly. After from eighteen to twenty hours' incubation, single hemolytic colonies suggestive of streptococcus were transplanted into beef infusion broth (+ 0.1) and grown for twenty-four hours, when cultural characteristics, staining reactions and morphology were noted. Bile solubility was done only when the pneumococcus was suspected. Fermentation reactions and the degree of hemolysis were not studied.

S. hemolyticus occurred in wide variation in numbers, from but one or two colonies on a plate to almost pure cultures. That this variation was not due to the method of plating was confirmed by repeated swabbing of individuals, with fairly constant findings. Exceptionally, on one day a single or possibly a few colonies might be found, whereas a subsequent culture would reveal none. It therefore seemed worth while to differentiate between the "slightly infected"—those whose cultures showed only an occasional hemolytic streptococcus colony—and the "heavily infected." Those cases were classed as negative in which cultures at no time showed the presence of *S. hemolyticus*.

Twenty sputum cultures were made by spreading a fragment of thoroughly washed sputum over the surface of a blood agar plate. Bronchial secretions were obtained when possible. Of thirteen cultures from streptococcus carriers and seven from noncarriers, all corresponded to the throat swab findings, thus demonstrating that the throat culture is apparently an index of the presence or absence of *S. hemolyticus* in the lower respiratory tract.

INCIDENCE OF STREPTOCOCCUS CARRIERS IN MEASLES PATIENTS ADMITTED TO THE HOSPITAL

Table 1 is self-explanatory. These figures are in striking contrast to the percentages prevailing at Fort Sam Houston, Texas, where only 11.4 per cent. of measles patients were carriers of *S. hemolyticus* on admission to the hospital.

Of the eighty-nine noncarriers admitted to the

wards, twenty-seven became infected during the period of their hospitalization. Contamination for the most part occurred during the early stages of the work, when the ward routine had not been firmly established. These cases are, of course, in the final analysis, classed with the carriers.

TABLE 1.—RESULTS OF THROAT CULTURES IN MEASLES ADMISSIONS

		Number	Per Cent.
Noncarriers		89	22.9
Carriers	Heavily infected	251	64.8
	Slightly infected	48	12.3
		299	77.1
Total		388	100.0

RELATIVE INCIDENCE OF COMPLICATIONS AMONG CARRIERS AND NONCARRIERS

Coryza, bronchitis and a laryngitis of variable severity, associated with an initial fever of from three to six days' duration, have been almost constant early accompaniments of each case. A majority of patients have been admitted on the second or third day of the disease, and fever occurring after the tenth day of hospitalization has been regarded as pathologic. Often it was indicative of a manifest complication; but of the uncomplicated cases, forty-seven, or 30.4 per cent., had transient, unexplained elevations of temperature frequently associated with headache and general malaise, but many times without symptoms or ascertainable cause. These unexplained febrile paroxysms, usually of from one to four days' duration, have formed an interesting, though puzzling, feature of the clinical course. They were noted a little more frequently among carriers (17.5 per cent.) than among noncarriers (12.9 per cent.).

Of the 388 cases, in 119, or 30.6 per cent., there were complications, a number of patients suffering from more than one. The complications are given in Table 2 in the order of their frequency.

An analysis of this table brings out a number of interesting points:

1. The complications of measles have occurred almost exclusively among streptococcus carriers, the incidence in this group being 36.8 per cent., as contrasted with 6.4 per cent. in "clean" cases. Furthermore, the four complications noted among the noncarriers have been of distinctly minor nature—two instances of acute bronchitis, one of acute tonsillitis, and one of cervical adenitis. In the slightly infected carriers, that is, those showing only an occasional colony in throat cultures, complications have occurred less frequently (22 per cent.) than in the heavily infected (38.2 per cent.).

TABLE 2.—COMPLICATIONS

Complications	Carriers		Noncarriers	Total	Remarks
	Heavily infected	Slightly infected			
Bronchopneumonia..	45	2	0	47	Fourteen of these patients are dead at the time of the present writing; some have been operated on for empyema; a number are still in the hospital
Acute tonsillitis.....	18	7	1	26	
Acute bronchitis.....	22	1	?	25	Not to be confused with the initial bronchitis
Actve suppurative otitis media.....	21	1	0	22	On culture, 9 specimens of pus showed S. hemolyticus; 2 Staphylococcus aureus
Empyema.....	15	0	0	15	All followed bronchopneumonia; on culture, 13 pleural fluids showed S. hemolyticus; 1, pneumococcus
Acute sinusitis.....	7	3	0	10	
Peritonsillar abscess	7	0	0	7	
Erysipelas.....	6	0	0	6	The face was affected in each instance
Cervical adenitis.....	4	1	1	6	Glands quite large, but never suppurated
Peritonitis.....	1	0	0	1	A terminal infection
Septic meningitis.....	1	0	0	1	A terminal infection
Totals.....	147	15	4	166	
	162		4	166	

2. Bronchopneumonia occurred forty-seven times, or in 12.1 per cent. of all cases. This complication has been responsible for many deaths; accurate mortality statistics are not available at the time of the present writing. In fifteen, or 34 per cent., of the bronchopneumonias, the patients have developed empyema.

3. On culture, thirteen pleural fluids showed *S. hemolyticus;* one, pneumococcus. From eleven speci-

mens of pus obtained in cases of acute otitis media, *S. hemolyticus* was grown nine times and *Staphylococcus aureus* twice.

4. Of 326 carriers, either entering the hospital as such or becoming infected after admission, 211, or 63.2 per cent., have had no complications.

ACQUISITION OF THE CARRIER STATE IN THE WARDS

Reference has already been made to Cole's observations on the ease with which *S. hemolyticus* may be spread from one individual to another in the ward of a hospital, though it is not mentioned that during the period of these observations cubicle isolation or other precautions to prevent the spread of infection were observed.

Experiments were therefore carried out in which wards were "mixed," that is, were filled half with "clean," half with "dirty" patients, in alternate beds. Newly admitted measles patients, convalescents and patients with complications composed the ward roster. All the precautions previously noted were rigidly enforced in order to prevent the contamination of "clean" by "dirty" patients. Yet in one ward, in which fifteen "clean" and fifteen "dirty" patients were placed, at the end of a week, only six noncarriers remained. In another ward of twenty-four, of whom at the start twelve were noncarriers, at the end of the week only three "clean" cases were found. Those patients who became "soiled" as the result of this period of exposure were for the most part classed as "slightly infected." These observations emphasize the importance of rigidly observing every precaution to prevent contact spread, though casting considerable doubt on the efficacy of the methods herein described. Therefore, when possible, if the incidence of complications is to be reduced, carriers and noncarriers should be separated, and cared for in different wards. Such a procedure should prove particularly valuable in camps where the number of streptococcus carriers among measles patients is low, as at Fort Sam Houston, Texas.

DIFFICULTIES OF ERADICATING THE CARRIER STATE

Throat cultures made at intervals in many of the "dirty" wards have shown that the carrier state, once acquired, persists throughout the patient's stay in the hospital. There have been rare exceptions to this rule.

Attempts at mouth disinfection have not been successful. Neutral solution of chlorinated soda in half strength, which has been in common use as a gargle and spray in this and other Army hospitals, will not kill *S. hemolyticus,* even in vitro. Experiments with other mouth antiseptics, notably iodin in glycerin, though successful in the test tube, have been clinically most disappointing. The organisms, apparently safely lodged in the crypts of the tonsils and in the lymphatic tissues of the nasopharynx, are not accessible to the local treatments so far employed. Of the patients discharged from the hospital, 71.7 per cent. still harbored *S. hemolyticus* in their throats.

EPIDEMIOLOGY

It was shown earlier in the year by one of us[4] that Camp Taylor was heavily infected with *S. hemolyticus,* and during the past four months representatives from almost every organization have entered the base hospital with lesions caused by this organism. In the present epidemic of measles, it was striking that of the 388 cases studied, 346, or 89.1 per cent., came from the One Hundred and Fifty-ninth Depot Brigade, an organization to which all new men entering camp are attached during the early period of their training. Accordingly, throat cultures were made on ninety-five men of Company 5 (Second Battalion), composed of individuals from various parts of the Brigade, most of them having been in service about six months. Of these, seventy-nine, or 83.2 per cent., were carriers of *S. hemolyticus,* 64.3 per cent. being heavily infected, 18.9 per cent. showing only an occasional colony on the plates.[5] All were apparently healthy.

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4. Alexander, H. L.: Hemolytic Streptococcus Causing Severe Infections at Camp Zachary Taylor, Ky., THE JOURNAL A. M. A., March 16, 1918, p. 775.

5. At Camp Custer, Battle Creek, Mich., Irons and Marine, during a period of respiratory infections, made a large number of throat cultures on selected companies. Hemolytic streptococci were found in about 70 per cent. of apparently healthy soldiers.

If these observations, made on a representative company, may be used as an index, a high percentage of soldiers in the Depot Brigade harbor *S. hemolyticus* in their throats. The question naturally arises, Do these men come from civil life as carriers, or do they acquire the organism in camp? The recent draft afforded an exceptional opportunity for determining this point. Throat swabs were taken on 489 new recruits, representatives of both urban and rural communities, as they stepped from the train. Of these cultures, 14.8 per cent. showed the presence of hemolytic organisms.[6]

The inference is obvious. It has previously been shown that Camp Taylor is heavily seeded with *S. hemolyticus*. A large number of the men, therefore, acquire the streptococcus carrier state during their sojourn in camp.

SUMMARY

1. Of 388 measles patients admitted to the base hospital at Camp Zachary Taylor, Ky., 299, or 77.1 per cent., were found to be carriers of *S. hemolyticus*.

2. A ward routine was instituted in an attempt to prevent the contamination of noncarriers by carriers in the hospital. All patients were admitted to a special "measles receiving ward," where throat cultures were made. Carriers of the streptococcus and noncarriers were there separated and sent to wards designated, respectively, as "dirty" and "clean." In these wards rigid precautions were observed, the most important of which were cubicle isolation, masking of patients and attendants, guarding of latrines to prevent crowding, the feeding of each patient in his own cubicle and, in the clean wards, supplying orderlies and nurses who, by throat cultures, had been proved noncarriers.

3. Complications occurred in 119 cases in the series (30.6 per cent.); a number of patients suffered from more than one. In order of frequency the complications were: bronchopneumonia, acute tonsillitis, acute bronchitis, acute suppurative otitis media, empyema, acute sinusitis, peritonsillar abscess, erysipelas, cervical adenitis, peritonitis and septic meningitis.

4. The complications occurred almost exclusively among streptococcus carriers, the incidence in this

6. The circumstances under which these cultures were taken made it impossible to define the colonies further.

group being 36.8 per cent., as contrasted with 6.4 per cent. in "clean" cases. Furthermore, the complications noted among the clean cases were of distinctly minor nature.

5. Bronchopneumonia occurred forty-seven times, or in 12.1 per cent. of all cases, and caused many deaths. Fifteen, or 34 per cent., of the bronchopneumonia patients developed empyema.

6. Cultures of pleural fluids and pus from ear discharges have, for the most part, shown *S. hemolyticus*.

7. Of 326 carriers, 211, or 63.2 per cent., have had no complications.

8. Even while observing the precautions outlined, "clean" patients became contaminated when a ward was "mixed," that is, filled half with carriers, half with noncarriers. These observations cast some doubt on the efficacy of the ward measures described.

9. Strictly "clean" wards remain "clean." Therefore, if the incidence of complications in measles is to be reduced, carriers and noncarriers must be separated and cared for in different wards. This procedure should prove particularly valuable in camps where the number of streptococcus carriers among measles patients is low.

10. Attempts at eradicating the carrier state by the use of mouth antiseptics have failed. Of the patients discharged from the hospital, 71.7 per cent. harbored *S. hemolyticus* in their throats.

11. Throat cultures were made on ninety-five men of a representative company in the One Hundred and Fifty-Ninth Depot Brigade, the organization from which came 89.1 per cent. of measles patients in this series. Seventy-nine, or 83.2 per cent., of the men in this company, though apparently healthy, were carriers of *S. hemolyticus*.

12. Throat swabs taken on 489 new recruits as they stepped from the train showed the incidence of streptococcus carriers to be 14.8 per cent.

13. A large number of the men at Camp Zachary Taylor, therefore, apparently acquire the streptococcus carrier state during their stay in camp.